ІНІЦІАТИВА З ПИТАНЬ ЗМІНИ КЛІМАТУ
CLIMATE CHANGE INITIATIVE

DELIVERABLE № 6, 2000

Training Program

Module 5: Greenhouse Gas Mitigation Analysis

Prepared for:
The United States Agency for International Development
under Contract LAG-I-00-98-00005-00, Task Order 16

Prepared by:
PA Government Services Inc.
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USA
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September 2000
Updated September, 2002

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Module Contents

Overview

Background

This module is the fifth in a series of nine, which comprise the Climate Change Initiative's (CCI) near-term training program in Ukraine. As a complete package, these nine are intended to build awareness among a wide group of stakeholders, on climate change issues.

Module Five, *Greenhouse Gas Mitigation Analysis*, is designed to provide an understanding of the methods and tools for assessing greenhouse gas reduction strategies within the context of countries with economies in transition

Materials for this module were adapted for Ukraine from existing packages and reports; namely the CC:TRAIN materials developed by the United National Institute for Training and Research (UNITAR), slide presentation materials developed by the Tellus Institute/Stockholm Environment Institute's Boston Center (Tellus/SEI-B), on behalf of the International Institute for Education (IIE), materials prepared by the United States Country Studies Program (USCSP), and materials developed by local specialists.

Participation

The ideal audience for this module includes mid-level energy ministry officials and non-governmental organizations. Other participants with a technical background in science, engineering, or economics will also benefit.

Objectives

The goal of this module is to impart an understanding of the process involved in conducting a greenhouse gas mitigation assessment. Each of the major topics are covered in the form of presentations by local or international specialists. These topics include: selection of technology options, choice of appropriate analytical tools, creation and evaluation of emission scenarios, and reporting the findings of an assessment.

Module Basics

- ***Duration***: 2 days
- ***Participants:*** 20-25
- ***Venue:*** Open
- ***Facilities (recommended):*** The module can be presented in any comfortable training facility. Adequate space for plenary presentations should be available.

- ***Format:*** Workshop; total of 13 sessions; consisting of a (typically) 45-minute long presentation, which includes a question and answer period, panel discussions, and working group exercises
- ***Instructors:*** 1 international specialist, several Ukrainian specialists
- ***Audio/Visual Needs:*** Overhead projector, overhead monitor
- ***Contacts:*** Natalia Kulichenko and Natalya Parasyuk of CCI, Dan Thompson (USAID), Bill Dougherty and Michael Lazarus of Tellus Institute

Materials

The module provides several types of material for use during both the preparation of the workshop, and the workshop itself. This material is outlined below.

Session Overview: The session overviews are "blueprints" for each of the thirteen sessions. The overview of each session provides a summary of the session, listing basic information, such as the general objective, total time, and type of activities involved.

Presenters are encouraged to:

- review this guidance material carefully,
- note the time it takes to deliver each slide
- mark comments and modifications in each page.

Overhead transparencies: OHTs are divided into sets according to sessions. Each set of OHTs is numbered consecutively and has titles based on their content. The precise order in which slides should be shown is presented in the corresponding Session Overview. Presenters are encouraged to give participants sufficient time to read and understand each OHT.

Reading and Resources: The topic of greenhouse gas mitigation analysis has a large reference library. Selected citations for key reports are included for further reference on the subject of mitigation assessment.

Evaluation Process

Module Five will need be evaluated in order to improve the workshop package for more effective subsequent use. The evaluation can be conducted using a simple questionnaire. At the close of the day, the workshop organizer should ask the participants to take five to ten minutes to complete the evaluation form. Participants need to be asked to put down their names on the forms.

Module References

Material for this module, including slides and presenters notes, was adapted from the following sources:

- CC:TRAIN Policy Development Series: Workshop Package on *Greenhouse Gas Mitigation Analysis*. http://www.unitar.org/cctrain/cd/techpaks/cc&unfcc/cd-reng/cc&unfcc_en.htm

- Tellus Institute and Alternative Energy Development (1999) *Economics of Climate Change Workshop Package.* Prepared for the International Institute for Education, under USAID.
- U.S. Country Studies Program, (1995) Guidance for Mitigation Assessments: Version 2

Agenda

The agenda for Module Five appears on the following page.

Agenda for Module 5: Mitigation

Day One:		
Session	***Topics to be covered***	***Time***
Opening Remarks	Welcome participants, introduce meeting structure, describe overall objectives and presenters, list day one topics	9:00 – 9:15
1. Introduction to mitigation Analysis	Introduce the basic purpose, structure, and steps involved in mitigation analysis	9:15 – 10:00
2. Ukraine's GHG Inventory	Summarize Ukraine's inventory, major GHG sources and sinks	10:00 – 10:15
3. Key mitigation concepts	Review major factors and steps that need to be considered when preparing a mitigation assessment	10:15 -- 11:00
Break		11:00 – 11:15
4. Technology Options	Review technology options available to each sector for GHG mitigation (energy, land use, industrial, waste)	11:15 – 11:45
5. Technology issues in Ukraine	Review status of technologies used for energy supply/demand and non-energy sectors in Ukraine; raise issues concerning vintage, use of advanced technology, barriers	11:45 --12:00
6. Mitigation Methods	Review main methodological approaches to mitigation	12:00 – 12:45
Lunch		12:45 – 1:45
7. Ukraine's GHG mitigation assessment	Review approach and main findings of Ukraine's existing assessment	1:45 -- 2:45
8. Roundtable Discussion on Ukraine mitigation assessment	Guide discussion on implications of the assessment, highlighting major technology transitions needed, potential barriers to use of advanced technologies, steps underway	2:45 - 3:15
Break		3:15 – 3:30
Working Group Exercise #1	Adapt LBL's technology screening exercise to Ukrainian conditions. This exercise will lead participants in identifying and ranking mitigation technology choices for Ukraine	3:30 -- 4:45
Closing Remarks	Summarize first day of module and outline second day. Solicit feedback, question/answer	4:45 – 5:00

Day Two:		
Session	***Topics to be covered***	***Time***
Opening Remarks	Welcome to participants, introduction of the day's topics, objectives and presenters, Review of previous day's activities. feedback, questions, and answers	9:00 – 9:15
9. Baseline Emission Scenarios	Review steps in creating national baselines, and identify specific steps for generating business-as-usual emission scenarios	9:15 – 10:00
10. Baseline issues in Ukraine	Review challenges in developing national baselines under current conditions in Ukraine, steps needed, institutional issues	10:00 --10:30
11. Analytical tools	Review the specific modeling tools used for mitigation analysis	10:30 -11:15
Break		11:15 – 11:30
Software Demonstration	*Provide an overview of LEAP2000 as a mitigation assessment tool*	*11:30 – 12:00*
12. Creating Mitigation Scenarios	Guide participants through the steps involved in developing future scenarios in which GHG emission mitigation is the primary motivation	12:00 – 12:45
Lunch		12:45 – 1:45
Working Group Exercise #2	Create a "dream" mitigation scenario for Ukraine	1:45 – 2:45
13. Reporting a Mitigation Assessment	Review steps involved in reporting a mitigation assessment that can be used by policymakers for addressing key issues and barriers. Provide concluding input	2:45 – 3:30
Break		3:30 – 3:45
Evaluation Session	Circulate training questionnaire	3:45 – 4:00
Closing Remarks	Revisit the aims of the two-day training and summarize the potential for future activity in this area	4:00 – 4:30

MODULE 5: CLIMATE CHANGE MITIGATION ANALYSIS

Session 1: Introduction to Climate Change Mitigation Analysis

Overview

General Objectives: By the end of the session, participants should have a basic understanding of the history, purpose and design of mitigation assessment. Specifically:

- The role of mitigation analysis within the UNFCCC
- The basic concepts behind climate change mitigation
- The primary steps and technical methods involved in carrying out a mitigation analysis
- Ukraine's specific circumstances, considerations and option, with regard to mitigation

Activities: An overhead slide presentation, followed by period of questions and answers

Total Time: 30 to 45 minutes

Materials: Set of 25 OHTs

Introduction to Climate Change Mitigation Analysis

Module 5: Session 1

CCI - Ukraine Workshop Package

Introduction to Mitigation Slide 1

Overview of Module 5:

This module will explore:

- The role of mitigation analysis within the UNFCCC
- The basic concepts behind climate change mitigation
- The primary steps and technical methods involved in carrying out a mitigation analysis
- Ukraine's specific circumstances, considerations and options, with regard to mitigation

Introduction to Mitigation Slide 2

What is Climate Change Mitigation?

- The greenhouse effect is a natural process which has become a global problem due to excess human emissions of Greenhouse Gases (GHGs)
- Climate change is the physical effects of a GHG build-up
- When GHG concentration = twice the pre-industrial level, the planet will be committed to a warming of 2 - 5º C.
- This could cause major changes in global and regional climate patterns during the next few decades.
- Climate change threatens to cause serious disruption to natural ecosystems and human societies.
- Mitigation is the process through which GHG emissions - and thus the impacts climate change - may be reduced.

Introduction to Mitigation Slide 3

Reduction in GHG Emissions Needed to Stabilize Atmospheric Concentrations at Present Levels

Greenhouse Gas:	Reduction Required:
Carbon Dioxide	>60%
Methane	15 - 20%
Nitrous Oxide	70 - 80%
CFC-11	70 - 75%
CFC-12	75 - 85%
HCFC-22	40 - 50%

Introduction to Mitigation Slide 4

Reducing Net Emissions

Reductions are made through changes in GHG Sources and Sinks

- Source: A natural or human activity that emits GHGs into the atmosphere. The most important human source of carbon dioxide is fossil-fuel combustion.
- Sink: A part of the biosphere that acts as a stable reservoir for GHGs. The oceans and the terrestrial plants are the most important sinks for carbon dioxide.

Net Emissions = Sources - Sinks

Introduction to Mitigation Slide 5

The World's Response to Climate Change

- **1988 - Formation of IPCC**
- **1992 - Signing of UNFCCC**
- **1997 - Agreement on Kyoto Protocol**
- **2001 - U.S. Withdraws support for Kyoto Protocol**
  - **Most other nations reach agreement on details of Kyoto implementation**

Introduction to Mitigation Slide 6

UNFCC Commitments (Article 4)

- Three categories of commitments:
  - general commitments that apply to all Parties
  - commitments that only apply to Parties listed in the Annex I
  - commitments that apply to Parties listed in Annex II
- The development of programs containing measures to mitigate climate change is included in the general commitments, and therefore applies to all Parties.

Introduction to Mitigation Slide 7

Flexibility Mechanisms

Between Annex I countries

- Emissions Trading (Article 17) - between Annex I countries to fulfill their reduction commitments. Any such trading shall be supplemental to domestic actions.
- Joint Implementation (Article 6) - fulfilling emissions limitation/reduction commitments jointly among Annex I Parties.
- Emissions Bubble (Article 4) - fulfilling emissions limitation and reduction commitments through sharing, between two or more Parties, of aggregated AA's.

Introduction to Mitigation Slide 8

Article 17: Emissions Trading

The Conference of the Parties shall define the relevant principles, modalities, rules and guidelines, in particular for verification, reporting and accountability for emissions trading. The Parties included in Annex B may participate in emissions trading for the purposes of fulfilling their commitments under Article 3. Any such trading shall be supplemental to domestic actions for the purpose of meeting quantified emission limitation and reduction commitments under that Article.

Introduction to Mitigation Slide 9

Article 6: Joint Implementation

1. For the purpose of meeting its commitments under Article 3, any Party included in Annex I may transfer to, or acquire from, any other such Party emission reduction units resulting from projects aimed at reducing anthropogenic emissions by sources or enhancing anthropogenic removals by sinks of greenhouse gases in any sector of the economy, provided that: […]

(c) It does not acquire any emission reduction units if it is not in compliance with its obligations under Articles 5 and 7; […]

Introduction to Mitigation Slide 10

Article 4: Bubble

1. Any Parties included in Annex I that have reached an agreement to fulfil their commitments under Article 3 jointly, shall be deemed to have met those commitments provided that [...].

Introduction to Mitigation Slide 11

Methods of Climate Change Assessment

- National Inventories of Greenhouse Gases
- Vulnerability Assessments
- Adaptation Analysis
- **Mitigation Analysis**
- Capacity-Building Needs Analysis

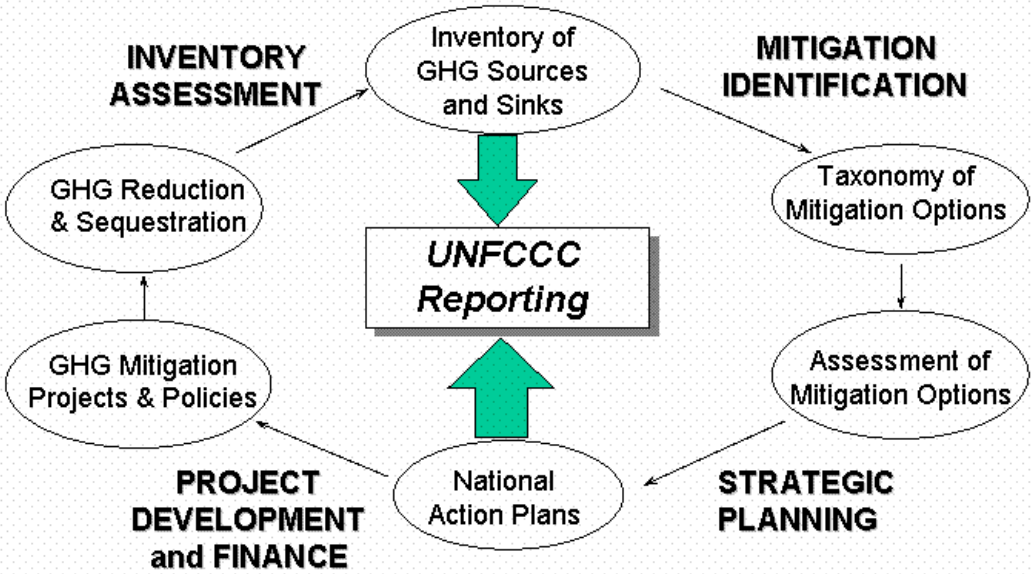
Introduction to Mitigation Slide 12

Role of Mitigation Analysis

- To present a set of viable options for reducing or sequestering GHGs
- To assess the cost of reducing GHG emissions through each set of options
- To rank these options and use them as building blocks for national or other mitigation strategy

Introduction to Mitigation Slide 13

UNFCCC, GHG Inventory and Mitigation



Introduction to Mitigation Slide 14

Commitments Specific To Climate Change Mitigation Analysis

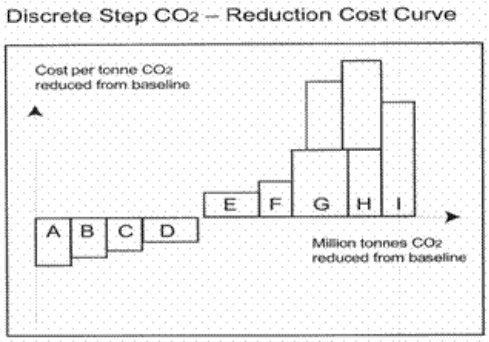
- Report periodically on programs to mitigate climate change
- Participate in technology transfer programs
- Promote enhancement of sinks
- Include climate change mitigation in development

Introduction to Mitigation

Slide 15

Why do Mitigation Analysis?

- The process meets UNFCCC principles and objectives.
- There may be "no regret" or "negative cost" options available that will also have GHG abatement benefits.



- In addition to global environmental benefits, mitigation options may have other national benefits

Introduction to Mitigation

Slide 16

Current Approach to Mitigation Analysis

- Define the boundaries of the system
- Review National GHG Inventory
- Establish a baseline case/scenario for GHG emission, technology, economy, costs and benefits, etc.
- Identify viable mitigation options that reduce GHG emissions or enhance sinks, *and* meet national development objectives
- Develop a mitigation case/scenario along the same parameters as the baseline, using analytical tools
- Compare baseline and mitigation cases based on costs and benefits

Introduction to Mitigation Slide 17

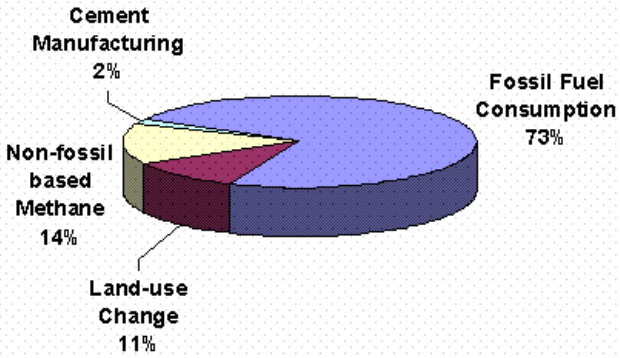
Major Greenhouse Gases

- The six GHGs controlled under the Kyoto Protocol are:
  - carbon dioxide (CO_2)
  - methane (CH_4)
  - nitrous oxide (N_2O)
  - sulphur hexafluoride (SF_6)
  - perfluorocarbons (PFCs)
  - hydrofluorocarbons (HFCs)

Introduction to Mitigation Slide 18

Global Sources of GHG Emissions

Anthropogenic GHG Emissions, 1991



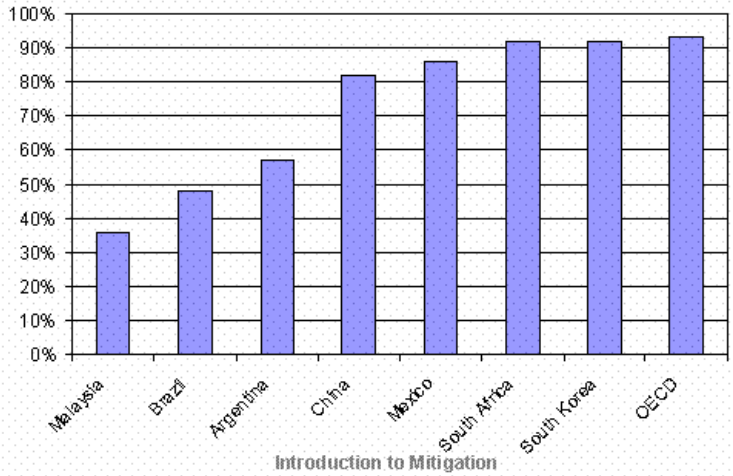
Introduction to Mitigation

Slide 19

GHG Emissions from Fossil Fuels

Fossil fuel based emissions dominate national GHG emissions.

Contribution of Fossil Fuels to Total National GHG Emissions



Introduction to Mitigation

Slide 20

Emissions From Energy Activities

- Fuel combustion, production, transport, storage, distribution
- Fuel combustion activities:
  a) Energy & Transformation Industries
  b) Industry
  c) Transportation
  d) Commercial/Institutional/Residential
  e) Agriculture/Forestry
  f) Biomass burned for energy
- Fugitive fuel emission:
  a) Oil and Natural Gas Systems,
  b) Coal Mining
- Mitigation options include efficiency improvements and renewable energy technologies

Introduction to Mitigation Slide 21

Emissions From Industrial Processes

- Greenhouse gases are by-products of the various production processes, including production of:
  - **Iron and Steel**
  - **Non-ferrous Metals**
  - **Inorganic Chemicals**
  - **Organic Chemicals**
  - **Non-metallic Mineral Products**
  - **Others**
- Mitigation options include efficiency improvements in both energy and materials use.

Introduction to Mitigation Slide 22

Emissions From Agriculture

– excluding fuel combustion

- **Enteric Fermentation**
- **Animal Wastes**
- **Rice Cultivation**
- **Agricultural Soils**
- **Agricultural Waste Burning**
- **Savannah Burning**

- Mitigation options include:
  - improved livestock and manure management
  - rice field nutrient and water management
  - fertilizer efficiency
  - conservation tillage

Introduction to Mitigation Slide 23

Emissions From Land-use Change and Forestry

- The most important land-use changes that result in CO_2 emissions and removals and release of non-CO_2 trace gases are:
  - Changes in forest and other woody biomass stocks
  - Forest and grassland conversion
  - Abandonment of croplands, pastures, plantation forests, or other managed lands
  - Changes in soil carbon
- Mitigation options include reforestation, enhanced regeneration and forest protection and conservation

Introduction to Mitigation Slide 24

Emissions From Waste

- Landfills
- Waste Water
- Human Sewage
- Waste Incineration

- Mitigation options include methane recovery and source reduction through reuse, recycling and composting.

Introduction to Mitigation Slide 25

MODULE 5: CLIMATE CHANGE MITIGATION ANALYSIS

Session 2: Ukraine's GHG Inventory

In compliance with the preliminary agenda we suggest the inclusion of the following theme:

- Ukraine's GHG Inventory

Information is updated depending on the development of new national climate change programs and strategies.

As an example we give presentation based on the First National Communication on issues of climate change (see Ukrainian version of Module 5).

It is recommended to invite authors of programs and strategies for presentation of their developments.

MODULE 5: CLIMATE CHANGE MITIGATION ANALYSIS

Session 3: Key Concepts in Mitigation Analysis

Overview

General Objectives: By the end of the session, participants should design of mitigation assessment. Specifically, participants should become familiar with:

- Commonly used terms in mitigation analysis
- The base structure and steps involved in conducting a mitigation assessment
- Major criteria used in the evaluation of technologies and policies used in mitigation analysis

Activities: An overhead slide presentation, followed by period of questions and answers

Total Time: 30 - 45 minutes

Materials: Set of 14 OHTs

Key Concepts in Mitigation Analysis

Module 5: Session 3

CCI - Ukraine Workshop Package

Definitions of Commonly Used Terms and Concepts in Mitigation Analysis

- Mitigation
- Abatement
- Mitigation Analysis
- Abatement Costing
- Baseline
- Baseline Definition
- Baseline Scenario
- Mitigation Scenario
- Emissions Inventories
- Emission Factors

Terms and Concepts (ctd)

- Assumptions
- Abatement Cost Curve
- Abatement Cost Function
- Technology Assessment
- Levelized Cost
- Reduction Target
- Reporting Period
- Base-year
- Sources And Sinks
- Negative Cost Options
- Transaction Costs

Key Concepts

Slide 3

Preparing For a Mitigation Assessment

- Set level (project, sector, national)
- Define the time frame of the assessment
- Define the scope of the assessment
- Define results that meet the users' needs
- Select approaches that are consistent with data availability and expertise

Key Concepts

Slide 4

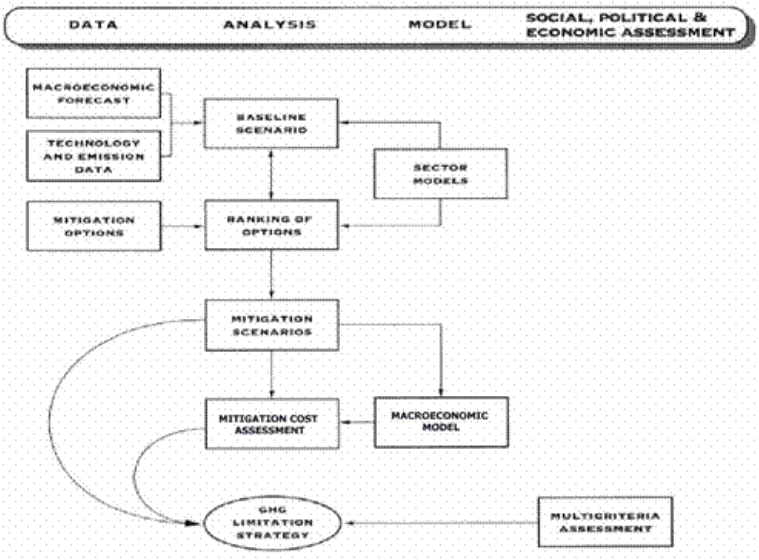
Steps In Mitigation Analysis

- There are Seven Key Steps in Mitigation Analysis:
  1. Comprehensive evaluation of national, social, and economic development circumstances
  2. Review of GHG inventory
  3. Baseline scenario projection
  4. Assessment of mitigation options (technology and policy)
  5. Mitigation scenario(s) projection(s)
  6. Mitigation cost assessment
  7. Assessment of implementation issues

Key Concepts

Slide 5

Structure of Mitigation Analysis



Key Concepts

Slide 6

Review National GHG Inventory Data to Identify Key Sources and Sinks

- The review is intended to show which sectors are likely to produce significant change through mitigation
- Inventories do *not* take into account future or planned development
- Inventories *may* be able to:
  - show the source and quantity of GHG emissions
  - indicate the factors contributing to these levels
  - provide a good guide to mitigation options within the existing development pattern

Key Concepts

Slide 7

Major Anthropogenic GHG Sources and Sinks

- SOURCE: Six major categories of human activities that result in GHG emissions:
  - energy production, transport, distribution, storage and consumption
  - certain industrial processes
  - use of solvents
  - certain agricultural practices
  - land-use change and forestry activities that remove vegetation
  - waste management
- SINK: Certain human activities result in the removal or sequestration of GHGs. These are classified under:
  - land-use change and forestry activities that enhance vegetation

Key Concepts

Slide 8

Sample Inventory:

SOURCE		CO_2 (Gg)	CH_4 (Gg)	N_2O (Gg)	NOx (Gg)	CO (Gg)
FUEL ACTIVITIES	CO_2 FROM ENERGY	3346.9				
	BIOMASS, NON-CO_2		24.9	0.1	2.8	174.9
FUGITIVE FUEL EMISSIONS	COAL PRODUCTION		0.1			
INDUSTRY	CEMENT PRODUCTION	234				
AGRICULTURE	LIVESTOCK		83.5			
	RICE CULTIVATION		58.7			
	SAVANNAH BURNING		0.0	2.1	48.4	26.3
	AGRICULTURE RESIDUES		0.7	0.0	0.5	14.7
LAND-USE CHANGE AND FORESTRY	CHANGES IN FOREST AND OTHER WOODY BIOMASS STOCKS	28167.2				
	ON-SITE BURNING OF FORESTS		52.8	0.4	8.6	462.4
	ABANDONMENT OF MANAGED LANDS	-26355.4				
WASTE	SOLID WASTE DISPOSAL SITES		68.9			
	MUNICIPAL WASTEWATER		14.8			
TOTAL		**5392.7**	**304.5**	**2.6**	**60.3**	**678.3**
GWP		**1**	**21**	**310**	-	-
TOTAL CO_2 Equiv.		**5392.7**	**7460.25**	**832**	-	-

Key Concepts

Slide 9

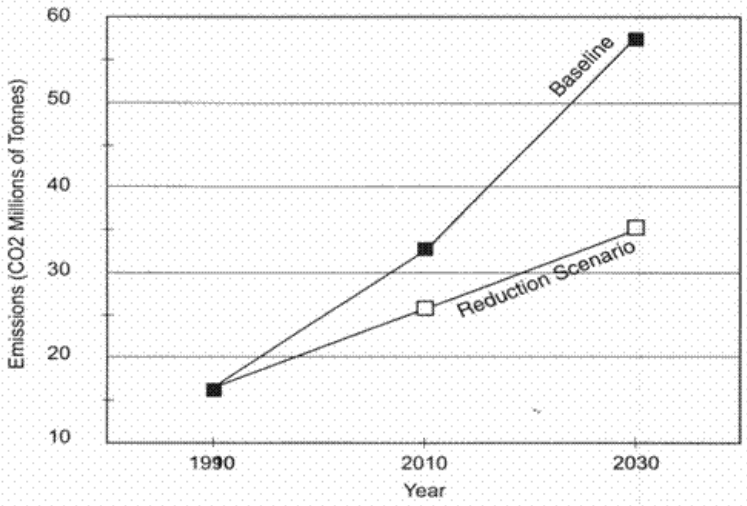
Key Parameters of Baseline and Mitigation Scenarios

- Baseline Scenario
  - Assumptions on social and economic parameters
  - Technology development and diffusion rate in the market
  - Natural resource prices
  - Domestic and international policy environment
- Mitigation Scenario
  - The above baseline parameters plus
  - Availability and market adoption rate of mitigation options
  - Mitigation scenario objectives
- *Developing scenarios is a complex task.*

Key Concepts

Slide 10

Sample Comparison of Scenarios



Key Concepts

Slide 11

Evaluation of Technologies and Policies

Economic and Social Criteria

- Cost-effectiveness
  - Average and marginal costs
- Project-level considerations
  - Capital/operating costs, opportunity costs, incremental costs
- Macro-economic considerations
  - GDP, jobs created or lost, effects on inflation or interest rates, implications for long-term development, foreign exchange and trade, other economic benefits or drawbacks
- Equity considerations
  - Differential impacts on countries, income groups and/or future generations

Key Concepts

Slide 12

Evaluation of Technologies and Policies

Environmental Criteria

- **GHG reduction potential**
  - metric tons of carbon equivalent
- **Other environmental considerations**
  - emissions reduction of other gases and particulates
  - effect on biodiversity
  - soil conservation
  - watershed management
  - indoor air quality, etc.

Key Concepts

Slide 13

Evaluation of Technologies and Policies

Institutional Criteria

- Administrative burden
  - Institutional capabilities for information collection, monitoring, enforcement, permitting, etc.
- Political considerations
  - Capacity to pass through political and bureaucratic processes and sustain political support
  - Consistency with other public policies
- Replicability
  - Adaptability to different geographical and socio-economic-cultural settings

Key Concepts

Slide 14

MODULE 5: CLIMATE CHANGE MITIGATION ANALYSIS

Session 4: Technology Options for Mitigation

Overview

General Objectives: By the end of the session, participants should have a basic understanding of the range of carbon reducing technology options across sectors in Ukraine. Specifically, a review of technological options is provided for the following sectors:

- Energy supply and demand
- Agriculture
- Forestry and land use
- Industrial processes
- Waste

Activities: An overhead slide presentation, followed by period of questions and answers

Total Time: 45 minutes

Materials: Set of 18 OHTs

Technology Options for Mitigation

Module 5: Session 4

CCI - Ukraine Workshop Package

Mitigation Options

Identifying and characterizing mitigation options is a key step on mitigation analysis:

- Options include technologies, practices and policies.
- Options should be described in sufficient detail to allow national level policy analysis.
- Current average options, best available practice, next available generation and potentially available (over study period) should be considered.

General Criteria for Screening Options

- Relative cost per unit of GHG reduction (cost of saved carbon)
- Potential for large impact on emissions
- Indirect impacts (e.g. employment, non-GHG emissions reductions)
- Consistency with development goals (equity, rural development, infrastructure, etc.)

Technology Options Slide 3

Applications of Technology Options: Sectoral Overview

- Energy
  - Supply
  - Demand
- Agriculture
- Forestry
- Industrial processes
- Waste

Technology Options Slide 4

Overview of Energy Technology Options

- **Energy Supply**
  - Conversion, transmission, distribution
  - Production and transport of fuels
- **Energy End Use**
  - Industry
  - Households
  - Buildings
  - Transportation
  - Agriculture
  - Waste

Energy Supply Sector

Technology Options for Mitigation

- More efficient conversion of fossil fuels
  - From average efficiency of 30% to 60%
- Switching to low-carbon fossil fuels
  - from coal to natural gas
- Power station rehabilitation
- Reduction of losses in transmission and distribution
- Improved fuel production and transport
  - recovery of coal mine methane
  - improved gas and oil flaring
  - reduction of pipeline leaks
  - coal cleaning and refining

Energy Supply Sector

Technology Options for Mitigation (ctd.)

- Advanced conversion technologies
  - advanced pulverized coal combustion
  - fluidized bed combustion (atmospheric and pressurized)
  - coal gasification and combined cycle technology
  - combined heat and power systems - cogeneration
  - fuel cells
- Switching to renewable sources of energy
  - hydropower
  - biomass
  - solar PV
  - solar thermal
  - wind energy
  - geothermal
  - ocean energy

Technology Options Slide 7

Energy End Use - Industrial Sector

Technology Options for Mitigation

- Development and application of more efficient technologies and processes
  - efficient boilers and furnaces
  - improved motor drive systems
- Fuel switching
- Cogeneration - combined generation of heat and power
- Process improvements
  - process integration
  - reduction of heat losses
  - good housekeeping
- Material substitution
- Material recycling and reuse

Technology Options Slide 8

Energy End Use - Transport Sector

Technology Options for Mitigation

- Energy Efficiency Improvements for Vehicles
  - Changes in vehicle and engine design
- Alternative Fuel Sources
  - hydrogen or electricity from renewable power
  - biomass fuels, CNG, LPG, etc.
  - fuel cell technology
- Infrastructure and System Changes
  - traffic and fleet management systems
  - mass transportation systems
  - modal shifts
- Transport Demand Management

Technology Options Slide 9

Energy End Use - Residential, Commercial, and Institutional Buildings

Technology Options for Mitigation

- Building Equipment
  - energy efficient heating (heat pumps)
  - efficient lighting, air conditioners, refrigerators, and motors
  - efficient cookstoves, household appliances, electric equipment
  - advanced building energy management systems
- Building Thermal Integrity
  - improved insulation and sealing
  - energy efficient windows
  - proper building orientation
- Utilizing Solar Energy
  - active and passive heating and cooling
  - effective use of natural light

Technology Options Slide 10

Agriculture Sector

Technology Options

Mitigation Options in Energy Use:

- Reduce fossil energy use in agricultural activities
- Increase the energy efficiency of agricultural equipment
- Reduce use of chemical fertilizers
- Application of conservation tillage systems
- Reduce energy use for irrigation
  - use of more efficient pumps
  - water conservation farming techniques
- Increase the use of renewable energy systems
  - solar PV and/or small wind turbines for water pumping
  - solar thermal systems for water heating, crop drying/processing
  - biomass power generation

Technology Options Slide 11

Agriculture Sector

Technology Options (ctd.)

Mitigation options in crop production:

- Increase carbon storage in agricultural soils
- Biomass production as a carbon offset
- Increase nitrogen fertilizer use efficiency
- Reduce methane emissions from rice production
  - nutrient management (increasing nitrogen fertilizer and reducing organic fertilizer)
  - water management (intermittent draining of rice fields)

Technology Options Slide 12

Agriculture Sector

Technology Options (ctd.)

Mitigation options in livestock production:

- Reduction of methane emissions from ruminant animals
  - improved nutrition through feed processing and supplementation
  - production enhancing agents
  - improved production through improvement in reproduction and genetic characteristics
- Adopting manure management practices
  - covered lagoons
  - small- and large-scale digesters

Technology Options Slide 13

Industrial Sector

Technology Options

- Energy-cost-sensitive options
  - Measures for existing processes (housekeeping, maintenance, cogeneration, heat recovery, etc.)
  - Measures for new, energy efficient equipment
  - Fuel switching to low-carbon options
- Non-energy-cost-sensitive options
  - Major modifications to production capacity
  - Addition of new production capacity involving state-of-the-art technology

Technology Options Slide 14

Forestry/Land Use

Technology Options

- Maintaining Existing Forest Stock
  - Increased efficiency in forest management, harvesting and product utilization
  - Sustainable production and use of biomass fuel
- Expanding Carbon Sinks
  - Improved agroforestry techniques (intercropping, boundary and contour planting)

Assessing Technology Options

- Generate a list of technological options for mitigation
- **Use data from existing studies on specific development projects or existing assessments to determine the following for each technology:**
  - Capital cost
  - Discount rate
  - Fuel costs
  - Penetration or diffusion rate
  - Emission factor for fuel used for each gas under assessment
  - Fuel consumption rate
  - Operating and maintenance costs
- **Generate the same data for the reference technology. This is the basic data for mitigation analysis. More specific data needs are shown below**

Sample Data Requirements — Generic Sub-Sector

Data requirements for GHG emissions estimation at each node

- **ENGINEERING PERFORMANCE DATA**
  - **Energy output**
    - Type
    - Range
  - **Energy input**
    - Input fuel
    - Input materials
    - Restrictions
  - **Thermodynamic efficiency**
    - Current, Future
  - **Performance limits**
    - Design, Maximum
    - Operational
  - **Construction Requirements**
    - Lead time
    - Construction period
    - Lifetime
    - Technology status
    - Commercial
    - Pilot/Research
- **ECONOMIC DATA**
  - **Cost**
    - Capital
    - Operating
  - **Financial**
    - Interest rate
    - Tax structure
    - Revenue Formulas
    - Foreign exchange
    - Escalation rates
- **ENVIRONMENTAL DATA**
  - **Emission rates**
    - Air pollutants
    - Water pollutants
    - Solid waste generation
  - **Control alternatives**
    - Equipment
    - Operational changes
  - **Control costs**

Technology Options Slide 17

For more information:

Examples, information and data on technology options are provided in:

- USCSP (1995) "Greenhouse Gas Mitigation Assessment: a Guidebook".
- IEA GREENTIE/CADDET (1999) "Energy and Environmental Technologies 1999"

Technology Options Slide 18

MODULE 5: CLIMATE CHANGE MITIGATION ANALYSIS

Session 5: Technology Issues in Ukraine

In compliance with the preliminary agenda we suggest the inclusion of the following theme:

- Technologies Issues in Ukraine

Information is updated depending on the development of new national climate change programs and strategies.

As an example we give presentation based on the First National Communication on issues of climate change (see Ukrainian version of Module 5).

It is recommended to invite authors of programs and strategies for presentation of their developments.

MODULE 5: CLIMATE CHANGE MITIGATION ANALYSIS

Session 6: Mitigation Methods - Selecting an Approach

Overview

General Objectives: By the end of the session, participants should have a basic understanding of the two major approaches in mitigation assessment. Specifically, the audience should become familiar with:

- The criteria to use in selection of modeling approach over another
- Types of bottom-up and top-down modeling tools available
- The data inputs required for each type of approach

Activities: An overhead slide presentation, followed by period of questions and answers

Total Time: 35 to 45 minutes

Materials: Set of 17 OHTs

Mitigation Methods: Selecting an Approach

Module 5: Session 6

CCI - Ukraine Workshop Package

Methods Slide 1

Review: Current Approach to Mitigation Analysis

- Define the boundaries of the system
- Review National GHG Inventory
- Establish a baseline case/scenario for GHG emission, technology, economy, costs and benefits, etc.
- Identify viable mitigation options that reduce GHG emissions or enhance sinks, *and* meet national development objectives
- Develop a mitigation case/scenario along the same parameters as the baseline
- Compare baseline and mitigation cases based on costs and benefits

Methods Slide 2

Steps in Developing an Approach

- **FIRST:** Decide on the methodological approach to be adopted for the analysis
- **SECOND**: Select the analytical tool/model to be used in the analysis
- **THIRD**: Bear in mind unique considerations of the analysis (e.g., data availability, skills required)

Methods Slide 3

Selecting a Methodological Approach

- **There are two basic approaches which have been used for mitigation analyses to date:**
  - **One is the bottom-up approach**
  - **The other is the top-down approach**

Methods Slide 4

Applications of the Bottom-up Approach

- Bottom-up approaches are suitable for:
  - project based climate change mitigation analysis
  - integration of independent technological interventions
  - short-term assessment of climate change mitigation
  - cases with insufficient macroeconomic data

Methods Slide 5

Strengths and Weaknesses of the Bottom-up Approach

- STRENGTHS
  - Shows measurable emission reduction potential on a project-by-project basis.
  - Shows measurable mitigation cost by each proposed activity.
  - Answers high priority short-term questions.
- WEAKNESSES
  - Methods to account for project-to-project interaction have not yet been formalized.
  - Too specific for long-term assessments of mitigation.
  - Cannot answer macroeconomic questions related to mitigation actions.

Methods Slide 6

Best Conditions For Applying Bottom-up Approach

- Bottom-up approaches are most useful where:
  - There is insufficient historical (macro-economic) data for trend analysis
  - There are dominant short-term development problems (such as in the energy sector)
  - There are major efficiency improvement options
  - A single dominant economic sector is emitting the majority of GHGs
  - There is insufficient expertise and/or data for macroeconomic modeling

Methods Slide 7

Bottom-Up Models for Mitigation Analysis

- Accounting Frameworks (e.g. LEAP)
- Optimization Models (e.g. MARKAL)
- Simulation Models (e.g. ENPEP)

Methods Slide 8

Types of Data Required for Bottom-Up Mitigation Analysis

- Technology: plant capacities, efficiency, fuels used/produced, lifetime, capacity factor
- Costs: fuel costs, capital, operating and maintenance (fixed and variable), program administration costs, other externality costs (e.g. non-GHGs)
- Market: installed capacity and vintage of plants in base year
- Environmental: Emission coefficients for CO2, CH4
- Trends: Technical potential, market penetration rates

Methods Slide 9

Outputs of Bottom-Up Analysis

- Amount of GHG emissions reduced (tons) by each option
- Cost of the investment (for the mitigation technology) relative to each ton of GHG reduced ($/ton CO_2)
- These costs are used to construct:
  - Mitigation cost curves
  - Mitigation scenario results (e.g. total % reduction relative to baseline)

Methods Slide 10

Limits to Bottom-Up Approach: Macroeconomic Questions

- Only captures direct economic costs, *not* impacts on GDP growth, employment, industrial structure, etc.
- Estimating macroeconomic effects requires linkage to macroeconomic model
- Feedbacks of macroeconomic effects may affect energy system.
- In a general equilibrium approach, whole system is interdependent.
- Such models are highly complex.

Methods Slide 11

General Description Of Top-down Approach

- **The top-down approach:**
  - involves macroeconomic modeling
  - involves complex econometric models
  - relies on a broad economic forecast
  - accounts for interaction between options (scenarios)
  - allows for regional assessment of climate change mitigation (coupling of options and economies)
  - requires data on linkages between economic sectors (usually input-output tables)

Methods Slide 12

Types of Top-down models

- Simple macroeconomic (econometric):
  - suitable for short-term analysis (up to 10 years)
- Input-output
  - captures intersectoral feedbacks but not structural changes in economies
- Computable general equilibrium
  - captures structural changes; assumes market clearing; suitable for full market economies (e.g. GREEN, Jorgenson-Wilcoxen, Tellus model)

Methods Slide 13

Strengths and Weaknesses of the Top-down Approach

- STRENGTHS
  - Can incorporate long-term effects of greenhouse gas mitigation
  - Captures cross sectoral effects of climate change mitigation measures
  - Allows for definition of regional scenarios
- WEAKNESSES
  - Not applicable to data deficient situations
  - Cannot span periods of major economic reform (as seen in many EIT and developing countries)
  - Has a high demand for analytical skills development
  - Analysis is usually wider than "field of view"

Methods Slide 14

INPUTS (data requirements) of Top-down Analyses:

- Autonomous efficiency coefficients
- Elasticities
- Trends in economic activities

OUTPUTS of Top-down Analyses:

- Carbon reduction
- Impact on GDP
- Jobs/Market transformation

Methods Slide 15

Best Conditions For Applying the Top-down Approach

- Top-down methods are best suited for:
  - Situations with adequate economic data
  - Economies with a low level of policy change (mature economies, such as developed countries)
  - Economies with close coupled sectors (industrialized countries)
  - Situations where macroeconomic policy options are dominant
  - Situations where analytical expertise is available

Methods Slide 16

For more information

- US Country Studies Program, Guidance for Mitigation Assessment: Version 2.0.
- UNEP Greenhouse Gas Abatement Costing Studies, Phase Two, Appendix: Guidelines by UNEP Collaborating Centre on Energy and Environment at Riso National Laboratories, Denmark.

Methods

Slide 17

MODULE 5: CLIMATE CHANGE MITIGATION ANALYSIS

Session 7: Ukraine's GHG Mitigation Assessment

In compliance with the preliminary agenda we suggest the inclusion of the following theme:

- Ukraine's GHG Mitigation Assessment

Information is updated depending on the development of new national climate change programs and strategies.

As an example we give presentation based on the First National Communication on issues of climate change (see Ukrainian version of Module 5).

It is recommended to invite authors of programs and strategies for presentation of their developments.

MODULE 5: CLIMATE CHANGE MITIGATION ANALYSIS

Session 8: Roundtable Discussion on the Ukrainian Mitigation Assessment

Overview

General Objectives: This session is a panel discussion of Ukrainian representatives (3 to 5) , moderated by either the international or local specialist. The purpose is to explore the implications of the GHG mitigation assessment presented in the previous session. A set of questions should be prepared beforehand by the moderator focusing on a) major technology transitions needed, b) potential barriers to use of advanced technologies, and c) any steps underway. Format allows for a question and answer period with rest of the participants.

Activities: Panel discussion on specific questions, followed by period of questions and answers

Total Time: 30 minutes

Materials: None

Working Group Exercise #1

General Objectives: This session is a working group exercise led by either the international or local specialist. Depending on the size of the audience, it can be led in the large group (if the workshop audience is less than 30 people), or by splitting up into 2 or more small groups (if the workshop audience is greater than 30 people). The purpose is to lead participants in a thought exercise to identify and rank mitigation technology choices for Ukraine according to given set of criteria. Additional criteria should be explored for relevance to Ukrainian conditions. This exercise is adapted from LBL's technology screening exercise found in the report entitled: "Greenhouse Gas Mitigation Assessment".

	Evaluation Criteria			
Mitigation Option	Costs	Environmental performance	Market transformation potential	Criterion 1 through n
Option 1				
Option n				

Activities: High level of audience participation in exploring best options for carbon-reducing technologies in Ukraine.

Total Time: 75 minutes

Materials: None

MODULE 5: CLIMATE CHANGE MITIGATION ANALYSIS

Session 9: Developing Baseline Emission Scenarios

Overview

General Objectives: By the end of the session, participants should have a basic understanding of the rationale and process behind baseline emission scenarios. Specifically:

- The purpose of developing baseline scenarios
- The specific steps involved
- The considerations that must be taken into account during the development process

Activities: An overhead slide presentation, followed by period of questions and answers

Total Time: 35 to 45 minutes

Materials: Set of 21 OHTs

Developing Baseline Emission Scenarios

Module 5: Session 9

CCI - Ukraine Workshop Package

Baselines

Slide 1

Why develop Baseline Scenarios?

- Baseline or "business- as-usual" scenarios are those in which there are no policies in place to reduce GHG emissions.
- National mitigation assessments need to consider the impacts of implementing climate change mitigation strategies in relation to baseline projections.

Baselines

Slide 2

Why develop Baseline Scenarios? (ctd.)

- Climate change mitigation involves the implementation of individual projects, sectoral strategies and comprehensive national action plans aimed at reducing GHG emissions.
- Comparison of mitigation scenarios with baseline scenarios can show the costs of climate change mitigation

Baselines

Slide 3

Issues in Establishing Baselines

- Efficiency of markets
- Degree of distortion due to pre-existing fiscal systems
- Influence of labor market distortion

Baselines

Slide 4

Common Scenarios Include:

- Activity projections for the main GHG emitting sectors and sinks
- Technological development related to the main GHG emitting sectors and sinks
- Technological development for mitigation projects
- Market behavior and implementation aspects related to mitigation projects
- Alternative assumptions for sensitivity cases
- Alternative policy instruments for achieving sectoral- and national-level goals

Baselines

Slide 5

Steps in Developing Baseline Scenarios

- Select/develop modeling approach
- Choose base year and time horizon
- Define baseline scenario; gather baseline economic and demographic trends and assumptions
- Examine trends in energy consumption, production, technology and fuel prices
- Review logic and consistency of scenario

Baselines

Slide 6

Framework for Estimating Mitigation Costs

Level	Baseline	Objectives	Options
MACRO	Macro level estimates of greenhouse gas emissions	National or global targets for emissions	Macroeconomic plus sectoral policies. Define set of options as set S1
SECTORAL	Project at sectoral level (e.g., energy, forestry)	Targets for sectoral reductions in emissions	Sectoral investment programs and policies. Define set of options as S2 ⇒ S2δ S1. Policies include mitigation.
PROJECT	Disaggregation of sectoral policies	Implementation of specific policies/investment programmes	Issues of design of detailed programmes and policies. Define set of options S3 ⇒ S3δ S2δ S1. Mitigation policies and investments to be covered.

Baselines

Slide 7

Level of Aggregation

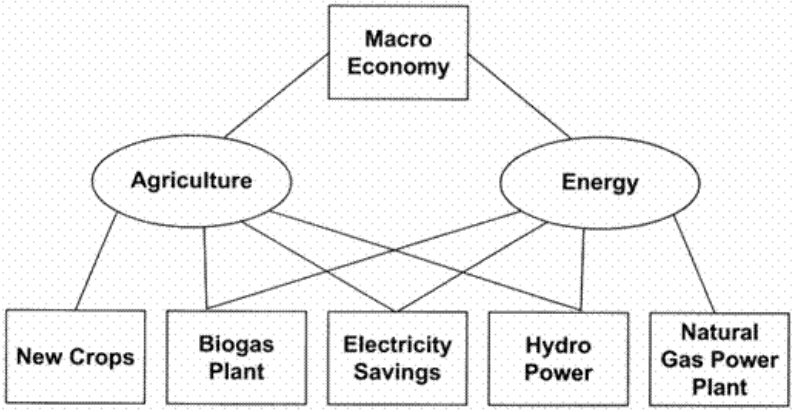
Level of Aggregation is the starting point for defining baselines

- Project assessment:
  - involves the implementation of individual mitigation projects
- Sectoral assessment:
  - involves the total impacts of implementing either a large number of mitigation projects in a sector or marketing structural changes to the system (such as large-scale fuel-switching)
- National assessment:
  - focuses on the total impacts of implementing mitigation projects and system changes in one or more sectors

Baselines

Slide 8

Example on Project Linkages Across Sectors



Baselines

Slide 9

Defining Baselines

Main types:

1. **The economic efficiency case:** reflects efficient resource allocation
2. **Business-as-usual case:** the baseline is constructed as a continuation of current trends
3. **The most likely case:** the compromise between the economic efficiency case and the business-as-usual case

Baselines

Slide 10

Developing the Baseline Scenario

- Select a base year
  - Convention guidelines recommend 1990. This, or another year where good data is available, may be used.
- Construct a table showing base year economic activity levels for each economic sector
  - Official sectoral output tables for that base year should be used.
- Determine base year energy intensities for each activity in GJ/unit activity
- For other gases (and for non-energy sources of CO2) determine GHG emission factors by activity level
  - This can be done without introducing the energy intensity component

Baselines

Slide 11

Base Year Activity Levels and Emission Factors

	GDP 1990		ENERGY AND ENERGY INTENSITY	
	MILL. Z$	%	TJ	TJ/MILL. Z$
AGRICULTURE	548	12.42	27695	50.54
MINING	313	7.09	9748	31.14
MANUFACTUR.	1101	24.94	53856	48.92
ELEC & WATER	156	3.53	N/A	35843
TRANSPORT	262	5.94	35843	136.81
MARKET SERVICE	840	19.03	5623	6.69
NON-MARKET SERVICE	1194	27.05	7992	6.69
GROSS DOMESTIC PRODUCT	4414	100	1404	31

Baselines

Slide 12

Energy Supply and Emission Factors

	TJ	EMISSION FACTOR kg CO_2/GJ
COAL	19520	95
WOOD	124950	0
HYDRO	12683	0
COKE	14784	108
ETHANOL	684	0
DIESEL	20962	74
PETROL	10176	73
AVGAS	155	73
LPG	265	65
JET A1	3638	72
PARAFFIN	1904	72

Baselines

Slide 13

Projecting Economic Activity Levels

- Using available information (preferably adopting official projections), forecast economic activity levels by sector from the base year through the end of the analysis period.
- Official projections may only be available for short and medium terms. In this case - "best guess" should be used to project through the end of the analysis period.

Baselines

Slide 14

Determinants of Baseline Projections

- Productivity
- Technological patterns
- Income and consumption patterns
- Policy decisions and their timing/enforcement
- Geographic distribution of activities
- Structural changes within industry
- Trade patterns and international specialization

Baselines

Slide 15

Projected Economic Activity Levels

CONSTANT 1980 Z$	GDP IN 1990		GDP IN 2010		GDP IN 2030	
	MILL.Z$	%	MILL.Z$	%	MILL.Z$	GROWTH RATE 2010-2030
AGRICULTURE	548	12.42	1159	10.68	1722	2.00
MINING	313	7.09	406	3.74	495	1.00
MANUFACTURING	1101	24.94	3751	34.57	70.3	3.20
TOT.PRODUCTIVE	1962	44.45	5316	48.99	9260	
ELECT. & WATER	156	3.53	484	4.46	719	2.00
TRANSPORTATION	262	5.94	739	6.81	1142	2.20
MARKET SERVICE	840	19.03	2587	23.84	6864	5.00
NON-MARKET SERVICE	1194	27.05	1726	15.91	4581	5.00
TOTAL SERVICE	2034	46.08	4313	39.75	11444	
TOTAL	4414	100.00	10851	100.00	22566	
GROWTH RATE % Per Annum 1990-2010			4.6			3.8

Baselines

Slide 16

Projecting Emissions from a Base Case Economic Scenario

- Determine annual energy use in the economy based on projected activity levels
- This should be done for each fuel type (e.g., gas, diesel, kerosene, coal)
- Attach emission factors to the fuel consumption values to derive emissions per year for each gas and from each fuel
- The result is emissions projections for the base case or "business-as-usual" scenario

Baselines

Slide 17

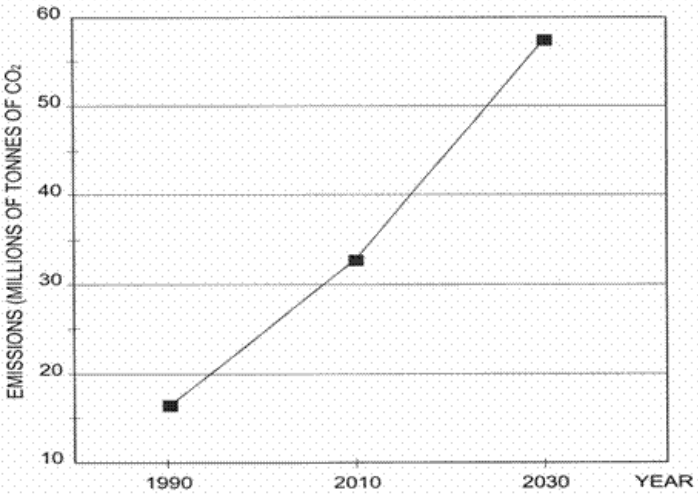
Energy Coefficient of Performance
(Energy Intensity of Production)

	1990		2010		2030		
	TJ	TJ/MILL.Z$	TJ	TJ/MILL.Z$	TJ	TJ/MILL.Z$	AEEI
AGRICULTURE	27695	50.54	58568	50.54	87029	50.54	0.0
MINING	9748	31.14	10358	25.52	10566	21.344	1.0
MANUFACTURING	53856	48.92	150378	40.09	236045	33.51	1.0
TRANSPORTATION	35843	136.81	87928	118.99	119843	104.95	0.7
MARKET SERVICE	5623	6.69	156.72	6.06	38011	5.54	0.5
NON-MARKET SERVICE	7992	6.69	10459	6.06	25368	5.54	0.5
GROSS DOMESTIC PRODUCT	1404	31	26131	6.06	63379	5.54	0.5

Baselines

Slide 18

Typical Baseline Emission Graphic



Baselines

Slide 19

Baseline Emission Data
(Million Tons of CO_2 Per Year)

	1990	2010	2030
COAL	13.41	26.27	47.92
WOOD	0	0	0
PARAFFIN	0.24	0.46	0.8
LPG	0.02	0.02	0.02
DIESEL	1.64	3.66	5.36
PETROL	0.74	1.64	2.36
ETAHNOL	0	0	0
AVGAS	0.01	0.03	0.04
JET A1	0.26	0.64	0.88
TOTAL	**16.32**	**32.72**	**57.38**

Baselines

Slide 20

For more information:

- US Country Studies Program (1995) *Greenhouse Gas Mitigation Assessment: A Guidebook*
- US Country Studies Program (1998) *Climate Change: Mitigation, Vulnerability and Adaptation in Developing and Transition Countries*

Baselines

Slide 21

MODULE 5: CLIMATE CHANGE MITIGATION ANALYSIS

Session 10: Analytical Tools – Selecting a Model

Overview

General Objectives: The focus of this session is on a review of modeling approaches used in mitigation analysis, and the major issues involved in selecting a model for conducting an assessment. By the end of the session, participants should have a basic understanding of some of the major "bottom-up" modeling tools available and how they might be applied in Ukraine. Specifically:

- An overview of the types of models in use
- Advantages and disadvantages modeling approaches
- General applications suitable for Ukrainian conditions
- Input, output and structures of a selected groups of bottom-up models

Activities: An overhead slide presentation, followed by period of questions and answers

Total Time: 45 minutes

Materials: Set of 25 OHTs

Analytical Tools:
Selecting a Model

Module 5: Session 10

CCI - Ukraine Workshop Package

Tools

Slide 1

Selecting the Analytical Tool/Model to be used in the Analysis

- Computerized analytical tools are essential for mitigation analysis.
- Models or simple spreadsheets can be constructed for a specific analytical purpose.
- A number of existing models and spreadsheet packages can be applied in mitigation analysis.

Tools

Slide 2

Examples Of Models In Use

BOTTOM-UP MODELS

- **STAIR** (Services, Transport, Agriculture, Industry and Residential energy model): flexible module for long-term energy scenarios
- **GACMO** (Greenhouse Gas Costing Model): spreadsheet module for project-based mitigation analysis
- **ETO**: compares energy supply sources to identify lowest cost options
- **COPATH** (Carbon Pasture Agriculture Total Harvesting): spreadsheet model for estimating carbon flows linked to forest use
- **LEAP** (Long-range Energy Alternatives Planning system): end use accounting modeling system for energy
- **EM** (Environmental Manual for power development): computerized tool includes environmental and cost data in decision-making for energy projects.

Tools

Slide 3

Examples Of Models In Use

TOP-DOWN MODELS:

- **Jorgensen-Wilcoxen -** Medium-term equilibrium/ resource allocation model designed to run in annual steps over a period of a few decades.
- **CGE -** Computerized general equilibrium models
- **DICE (Nordhaus)** Dynamic Model of Climate and the Economy (DICE), which incorporates assumptions regarding the costs and benefits of greenhouse gas emissions in a standard one-sector growth model.

NB: many models combine the bottom-up and top-down characteristics at varying levels

Tools

Slide 4

Overview of Selected Models

Model Characteristics	STAIR	LEAP	ETO	MARKAL	ENPEP	MARKAL-MACRO
Model Type	Energy Accounting	Energy Accounting	Engineering Optimization	Engineering Optimization	Iterative Equilibrium	Hybrid
Number of Non-Energy Sectors	0	0	0	0	-	1
Energy Supply Representation	Process Analysis	Process Analysis	Process Analysis	Process Analysis	Supply Curves	Process Analysis
Energy Demand Representation	Exogenous	Exogenous	Exogenous	Exogenous	Exogenous	Utility Maximization
Multi-period	No	No	No	Yes	Yes	Yes
Consumer/Producer Foresight	Not applicable	Not applicable	Not applicable	Perfect or Myopic	Myopic	Perfect or Myopic
Solution Algorithm	Accounting	Accounting	Linear Programming	Linear Programming	Iteration	Non-Linear Optimization

Tools

Slide 5

Considerations for Selecting the Analytical Tool/Model

- Many reasons for selecting a specific tool or model
- Objective is to generate practical mitigation analysis results that are relevant to the specific situation of interest
- Important to choose a model which:
  - has data input requirements that match data structures already available
  - has data structures already used in official national statistics, planning procedures, and documents

Tools

Slide 6

Considerations for Selecting the Analytical Tool/Model (ctd.)

- Model needs to be simple enough that it does not hinder or delay the analytical process
- Complex models should be supported by back-up training
- The output structure of the model results is very important
  - it may be useful to select a model whose output structures can be readily used by stakeholders
  - this sort of output may be used for implementation of the national mitigation strategy

Tools

Slide 7

Types of Bottom-Up Models for Mitigation Analysis

- Accounting Frameworks (e.g. LEAP)
- Optimization Models (e.g. MARKAL)
- Simulation Models (e.g. ENPEP)

Tools

Slide 8

Optimization Models

- Typically use linear programming to minimize total cost of providing energy services.
- Cost-minimization can be performed within specified constraints (e.g. on CO_2 emissions, technology availability, etc.)
- Relatively simple to use
- Example: MARKAL

Tools

Slide 9

Simulation Models

- Simulates operation of energy system: the behavior of energy consumers and producers under various signals (e.g. price, income levels) and constraints (e.g. limits on rate of stock replacement).
- May include demand-supply feedbacks
- Can be difficult to parameterize
- Example: ENPEP

Tools

Slide 10

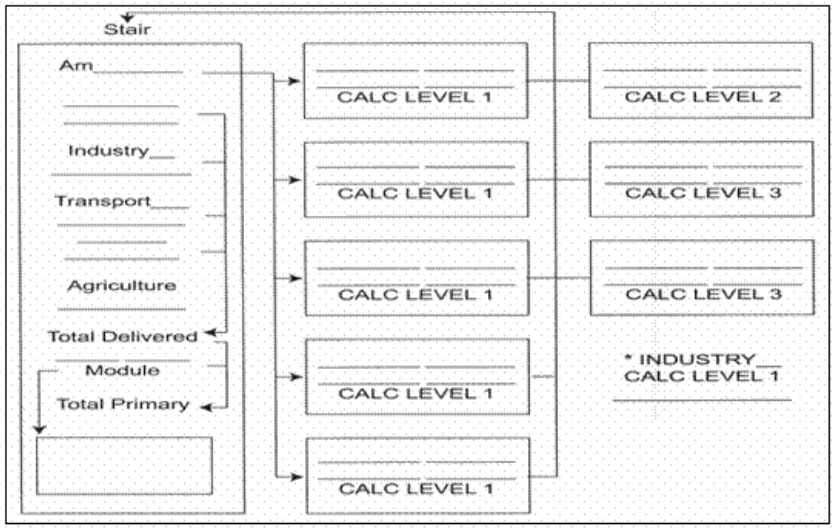
Accounting Frameworks

- Typically account for flows of energy in system based on simple relationships (e.g. conservation of energy)
- Rather than simulating decisions of energy consumers and producers, user explicitly accounts for outcomes of those decisions (e.g. in terms of market penetration rates, actual levels of consumption).
- Simple, readily understandable, easy to parameterize.
- Examples: LEAP, STAIR

Tools

Slide 11

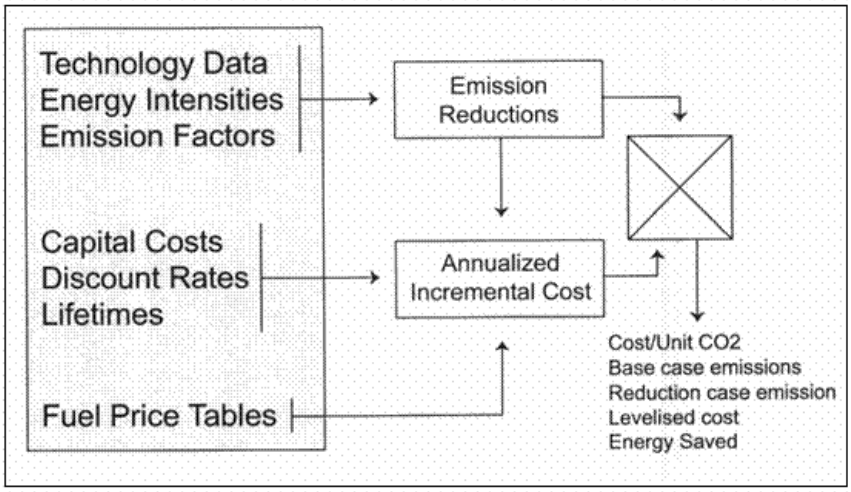
STAIR Model Structure



Tools

Slide 12

GACMO Overview



Tools

Slide 13

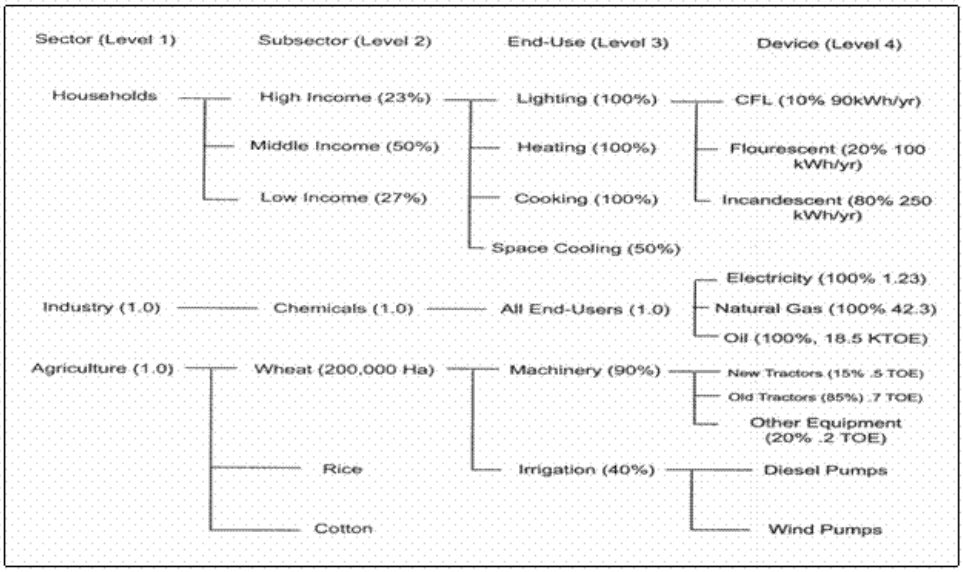
Simple Equations Used In GACMO

- GHG EMISSIONS = $\frac{\text{EMISSION FACTOR * ENERGY USED}}{\text{DEVICE EFFICIENCY * CONVERSION EFFICIENCY}}$
- EMISSION REDUCTION = BASELINE EMISSIONS - MITIGATION CASE ENERGY
- LEVELISED FUEL COST = NPV * (i /(1-(1+i)-N)
  - Where NPV is net present value of fuel cost over project lifetime
- LEVELISED CAPITAL COST = NPV OF PMT * (i /(1-(1+i)-N)
  - Where NPV of pmt is the net present value of the annualized capital cost (over project lifetime)
- REDUCTION COSTS = $\frac{\text{TOTAL COST}}{\text{EMISSION REDUCTION}}$

Tools

Slide 14

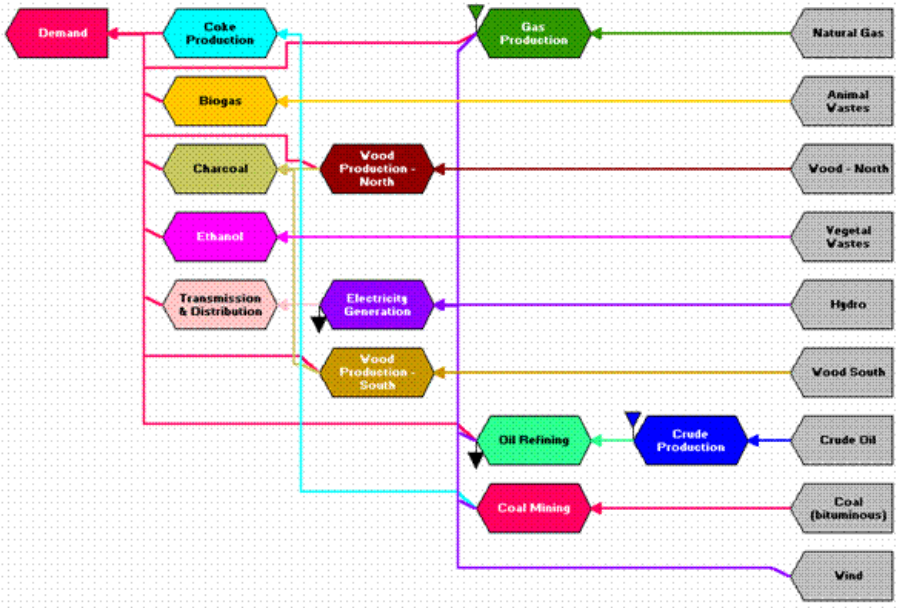
Typical Input Data for LEAP



Tools

Slide 15

LEAP2000 Diagram View



Tools

Slide 16

Typical Output for LEAP

BASELINE ENERGY DEMAND BY FUEL IN COUNTRY (1000 TOE)					
	1990	2000	2010	2020	2030
ELECTRICITY	65.21	93.98	137.35	195.62	281.69
GASOLINE	72.30	114.83	174.64	270.70	402.77
KEROSENE	10.78	18.32	27.82	39.91	55.16
DIESEL	28.33	36.48	51.12	74.27	106.81
FUELOIL	36.84	44.88	54.66	66.59	81.13
LPG	3.53	6.33	10.16	14.72	21.21
COAL	22.01	26.79	32.62	39.72	48.36
FIREWOOD	55.59	55.92	57.70	62.28	64.44
CHARCOAL	2.3	2.50	2.83	2.83	3.23
TOTAL	296.89	400.03	548.45	766.66	1064.81

Tools

Slide 17

Typical Output for LEAP (*ctd.*)

PERCENT SHARE BY FUEL					
	1990	2000	2010	2020	2030
ELECTRICITY	21.97	23.49	25.04	25.52	26.45
GASOLINE	24.35	28.71	31.84	35.31	37.83
KEROSENE	3.63	4.58	5.07	5.21	5.18
DIESEL	9.54	9.12	9.32	9.69	10.03
FUELOIL	12.41	11.22	9.97	8.69	7.62
LPG	1.19	1.58	1.85	1.92	1.99
COAL	7.41	6.70	5.95	5.18	4.54
FIREWOOD	18.72	13.98	10.52	8.12	6.05
CHARCOAL	0.78	0.63	0.43	0.37	0.30
TOTAL	100	100	100	100	100

Tools

Slide 18

LEAP: Selected Baseline Environmental Emissions In-Country

	1990	2010	2030	
CARBON DIOXIDE	26.75	57.67	124.11	BILL KG
CARBON MONOXIDE	477.21	819.63	1623.00	MILL KG
METHANE	84.12	214.52	419.85	MILL KG
NITROGEN OXIDES	95.94	180.56	371.27	MILL KG

Tools

Slide 19

Uses of MARKAL

MARKAL is a flexible dynamic linear programming model that can be used to represent various energy systems over a medium to long time horizon, at the community, region, or country level.

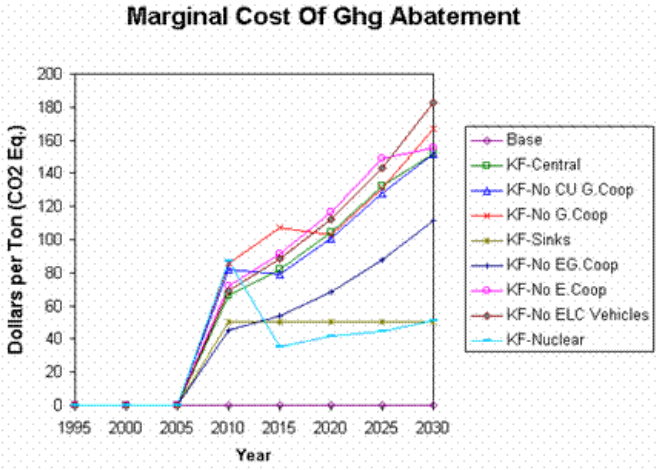
MARKAL can be used to:

- identify least-cost energy systems
- identify cost-effective responses to restrictions on emissions
- perform prospective analysis of long-term energy balances under different scenarios
- evaluate new technologies and priorities for R&D
- evaluate the effects of regulations, taxes, and subsidies to project inventories of greenhouse gas emissions

Tools

Slide 20

Example of MARKAL Application



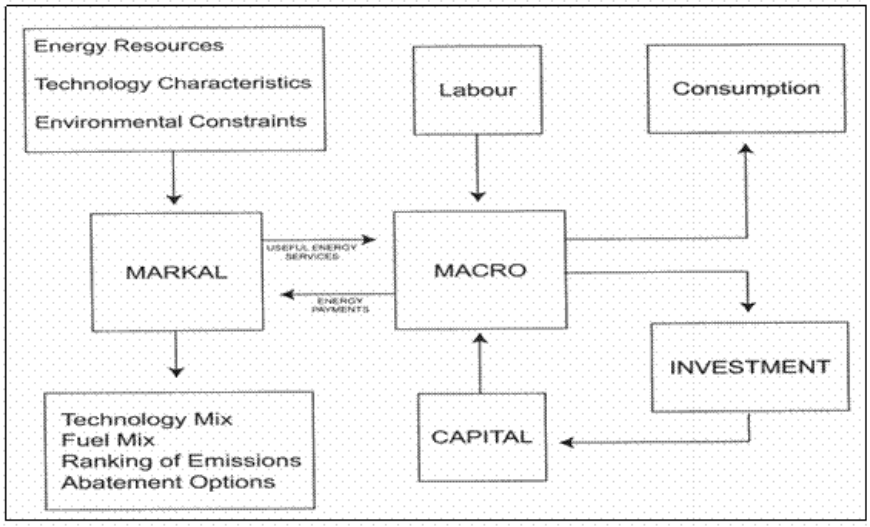
This graph, developed with a multi-region MARKAL model illustrates marginal mitigation costs for the Canadian Province of Quebec, under various scenarios of Kyoto Protocol implementation

(Source:http://www.crt.umontreal.ca/~amit/kyotoscenarios/bform-comp.htm)

Tools

Slide 21

Overview of MARKAL-Macro



Tools

Slide 22

Typical Mitigation Analysis Routine Using Spreadsheets

- **Establish a reference scenario:**
  - **based on macroeconomic growth projections and emission data**
  - **guided by the overall assumptions of the project**
- **Select mitigation options:**
  - **rank these according to cost and emissions, compared to the reference case**
  - **include other non-financial costs in the analysis**
- **Make a set of scenarios:**
  - **include the various sectors of the economy**
  - **account for interaction between sectors in the analysis**
- **Assess the macroeconomic impacts of the scenarios**
- **Evaluate the scenarios:**
  - **consider the social, political and economic desirability of the options**

Tools

Slide 23

Summary of Issues in Selecting an Analytical Tool:

- Transparency
- Fit with data quality and availability
- Goals of the mitigation assessment
- Level of disaggregation of results

Tools

Slide 24

For more information

Selected websites:

- LEAP: http://www.seib.org/leap/index
- MARKAL: http://www.ecn.nl/unit_bs/etsap/markal
- ENPEP: http://enpep.dis.anl.gov/mosaic/enpep
- EM: http://www.worldbank.org/html/fpd/em/model/em_model

Tools

Slide 25

MODULE 5: CLIMATE CHANGE MITIGATION ANALYSIS

Session 11: Developing Mitigation Scenarios

Overview

General Objectives: By the end of the session, participants should have a basic understanding of the process of developing and using mitigation scenarios. Specifically:

- The objectives of mitigation scenarios
- The steps involved in creating mitigation scenarios
- The parameters and criteria to be considered
- The main steps and issues involved in calculating mitigation costs

Activities: An overhead slide presentation, followed by period of questions and answers

Total Time: 45 minutes

Materials: Set of 21 OHTs

Developing
Mitigation Scenarios

Module 5: Session 11

CCI - Ukraine Workshop Package

Mitigation Scenarios

Slide 1

Steps in Creating and Evaluating Mitigation Scenarios

- Establish scenario objectives
- Define key parameters
- Define mitigation option screening criteria
- Create option portfolios and estimate penetration rates

Mitigation Scenarios

Slide 2

Steps in Creating and Evaluating Mitigation Scenarios (ctd.)

- Construct integrated scenarios
- Calculate overall costs and GHG mitigation potential
- Account for uncertainty (sensitivity analysis)
- Review impacts not captured by model

Objectives of Mitigation Scenarios

- Emission reduction target (relative to baseline or base year)
- Options up to a certain cost per unit of emissions reduction (equivalent to carbon tax)
- "No regrets" (cost-effective options only)
- Specific options or technologies

Key Mitigation Scenario Parameters

- Discount rate/time horizon
- Mitigation costs/benefits (societal or market perspective?)
  - Direct costs: equipment, operations and maintenance, fuel costs, administration.
  - Externalities: economic (e.g. infrastructure) and non-GHG environmental externalities.
- Avoided emissions

NB: See UNEP Methodology Guidelines

Mitigation Scenarios

Slide 5

Criteria for Screening Options

Criteria	Mitigation Option 1	Mitigation Option 2	Mitigation Option n
Potential for large impact on CO_2 or other GHGs	High	Low	Medium
Direct cost/benefit ratio of the option	Low	High	High
Indirect economic impacts • Increase in domestic employment • Decrease in import payments	 Medium Low	 Low Medium	 Low Uncertain
Consistency with national environmental goals • Reducing emissions of air pollutants • Effectiveness in limiting other environmental impacts	 Low Medium	 High Low	 Medium Low
Potential ease of implementation	Low	Medium	High
Long-term sustainability of option	High	Uncertain	Medium
Consistency with national development goals	High	Low	Medium
Data availability for evaluation • Technology characterisation • Costs of implementation programs	 Low High	 Uncertain Low	 High Uncertain
Other sector-specific criteria	Low	High	Uncertain

Note: Numerical rankings may also be used.

Mitigation Scenarios

Slide 6

Examples Of Mitigation Options

1. Energy sector
- End-use efficiency improvements in households, industry, services
- Transmission systems
- Fuel substitution
- Renewable technologies (decentralized)
- Supply technologies (centralized): fossil fuels, nuclear and renewables

2. Agricultural sector
- Fertilizer control schemes
- Introduction of crops with enlarged carbon sequestration capability
- Livestock management, manure treatment
- Cultivation of rice paddies

3. Forestry sector
- Afforestation projects for increased carbon sequestration
- Recycling of permanent carbon storage from harvested biomass
- Reforestation for increased carbon sequestration

4. Transportation
- Efficiency improvements for vehicles
- Switch to fuel systems with lower emissions
- Improve transport system efficiency
- Modal shifts
- Manage transport demand

5. Waste management
- Gas recovery from landfills
- Biogas plants
- Recycling
- Composting

6. Industry
- Cement production
- Aluminum production

Mitigation Scenarios

Slide 7

Sample Reduction Option

REPLACEMENT OF INCANDESCENT LAMPS (IL) BY FLUOCOMPACT LAMPS (FCL)		
	IL	FCL
Electric Consumption (kWh/y)	200	50
Cost of lamps (F)	500	5000
Cost of the kWh (F)	100	100
Carbon Coeff. (kg/kWh)	0,22	0,22
Other impacts	xxx	yyy

SCENARIO OF REPLACEMENT OF 3 IL BY 3 FCL			
	Reference	Reduction	Impact (Red. - Ref.)
Cost of lamps (F)	3 x 500 = 1500	3 x 5000 = 15000	13500
Electric consumption (kWh/y)	3 x 200 = 600	3 x 50 = 150	-450
Carbon Emission (kg)	600 x 0,22= 133	150 x 0,22 = 33	100
Cost of total consumption per year (F)	600 x 100 = 60000	150 x 100 = 15000	-45000

Cost-benefit indicator (cost of kg reduced) = (13500 - 45000) /100 = -315 F/kg/year
The incremental cost for one million of households is: 31,500 x 1 million = 31.5 billion F

Mitigation Scenarios

Slide 8

Key Assumptions

- **Fuel Prices**
  - factor costs or market prices?
  - influence of international markets; consistency with other studies
- **(Autonomous) Energy Efficiency Improvement**
  - ability to improve efficiency can be linked to economic growth, and access to state-of-the-art technologies
  - rates of 0.5%-3.0%/year have been observed across countries
- **Penetration/Diffusion Rates**
  - are a function of demand, income, and product lifetime/stock turnover (stock modeling)
  - can be accelerated by programme activity that provides incentives and overcomes market barriers

Mitigation Scenarios

Slide 9

Penetration Rates

- Includes
  - timing and size of discrete supply side options
  - market penetration of smaller investments
- Can be influenced by:
  - Economic factors (energy prices, income levels, etc.)
  - Equipment lifetime (may require stock modeling).
  - Technical, infrastructure and financing limitations (e.g. availability of foreign exchange).
  - Policy instruments used (e.g. standards, incentives).

Mitigation Scenarios

Slide 10

Sample Assumptions

SCENARIO ASSUMPTIONS

BASE CASE		ABATEMENT
10-30 %	Improvement of Industrial Energy Intensities	5-45%
5-20%	Decrease on Specific Residential Consumption	10-30%
	Switching to Natural Gas and Electricity	
5-20%	Improvement of Vehicle Energy Efficiency	10-30%

Mitigation Scenarios

Slide 11

Main Steps In Calculating Mitigation Cost

1. Calculate the source for a more efficient development scenario (mitigation options)
   - Emissions$_{YR}$ = Source * Emission Factor *and* Source = ò$_i$ (A * I)$_i$
   - Where source is specified in units matching the emission factor A = Activity level; I = Intensity; Both for the year i for which projection is being made
   - (SOURCE)*eff* = (î*i* (A*I)*i*)*eff*
2. Calculate the cost of the reference case and the mitigation case using the following general equation
   - COST = îi (Ai*Ii*Ci) (C stands for Cost)

Mitigation Scenarios

Slide 12

Main Steps In Calculating Mitigation Cost (ctd.)

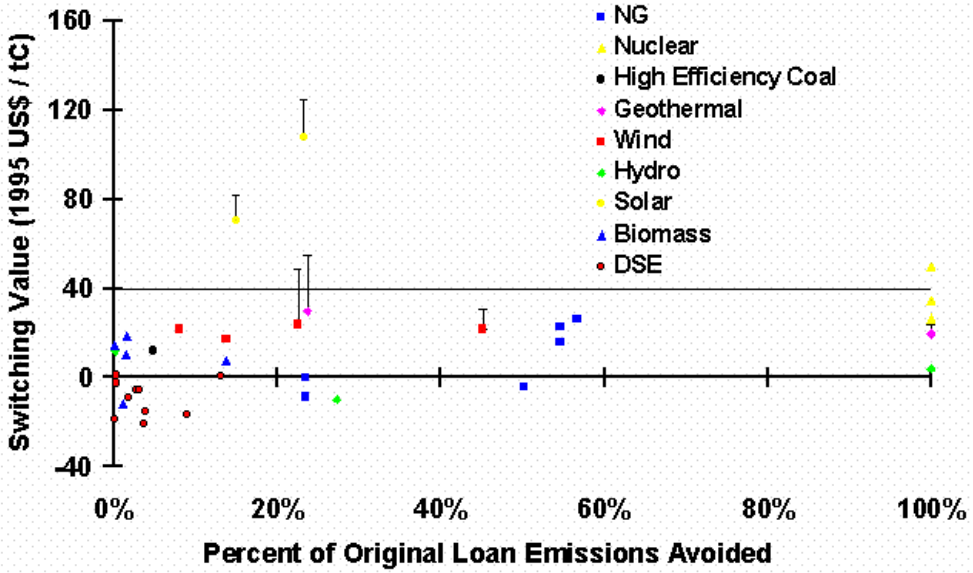
3. Calculate the mitigation cost:

$$\frac{COST_{eff} - COST_{ref}}{EMISSION_{ref} - EMISSION_{eff}}$$

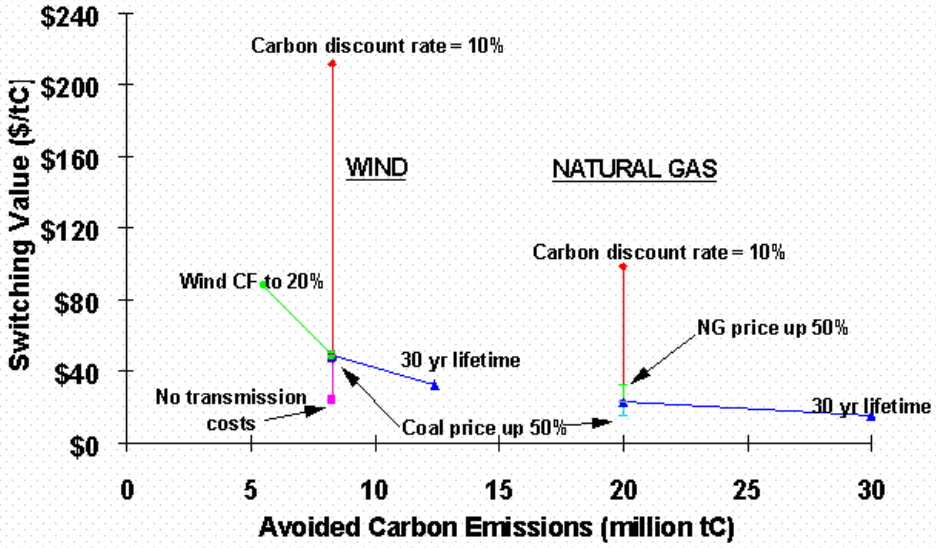
– Where *"ref"* is for the non-mitigation or reference case and *"eff"* is for the mitigation case

Source: UNEP Greenhouse Gas Abatement Studies, Phase Two, Part One: Main Report, Page 17, and U.S. Country Studies programme, Guidance for Mitigation Assessments: Version 2, page 3-7

Power Supply (PS) Alternatives



Sensitivity Analysis: Yangzhou China



Why discount?

- Economic growth

  A dollar in my pocket can be invested in a growing economy today. Thus, a dollar today is worth more than one I might receive a year from now.

- Inflation

  The spending power of my dollar will decrease over time as prices rise.

- Risk

  I might have a hole in my pocket and lose the dollar!

- Pure time-preference

  I would just rather have it now.

Mitigation Scenarios

Slide 16

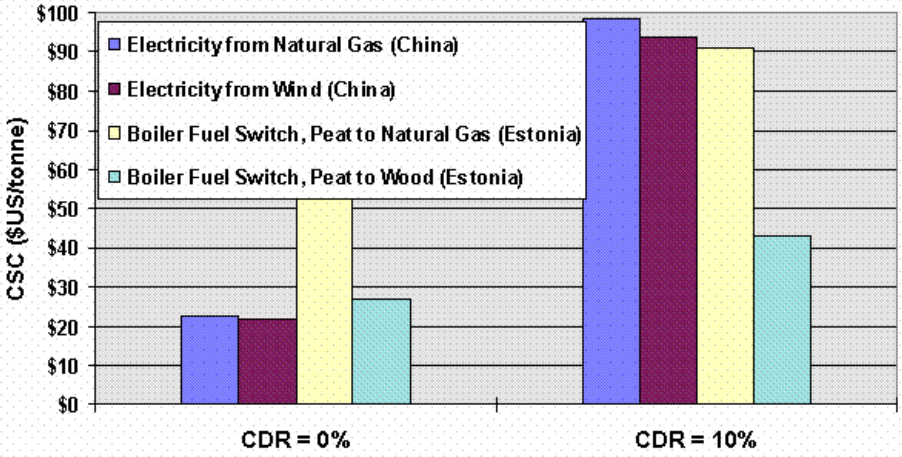
To D or not to D? That's the Carbon Question

- CSC (cost of saved carbon) is the common unit for reporting and comparing costs of GHG mitigation options.
- Reported CSCs typically embody a time preference for emission savings or "carbon discount rate" (CDR). This rate is often equal to the monetary discount rate used.

To D or not to D? (ctd.)

- Discounting C at 7% suggests it's better financially to save 1 ton C today than 2 tons C in 10 years. However, this is worse for the climate.
- CSCs for a given abatement measure can vary by a factor of four or higher, depending on CDR method used.
- Carbon discounting approach seldom noted literature.
- Lack of consistent approach can lead to misleading.

GHG Abatement Measures from World Bank Study (1997) at Alternative Carbon Discount Rates (CDR)



As CDR goes from 0% to 10%, the relative CSC ranking of the electricity vs. boiler fuel switching measures switch, due to the more near-term emission reductions of the boiler projects.

Mitigation Scenarios

Slide 19

Alternative approaches to CDR

- No discounting (e.g., GEF practice, some AIJ studies);
- Use standard CSC levelization formula, CDR = monetary discount rate (5 lab study, Energy Innovations, many country studies, IPCC SAR WG2)
- Derive from emissions targets over time (Anderson, WB)
- Reflect relationship between the timing of emissions and value of marginal damages (WB backcasting study)
- Derive from investor behavior if and when CER markets are created

Mitigation Scenarios

Slide 20

For more information

- UNEP Greenhouse Gas Abatement Studies, Phase Two, Part One: Main Report
- U.S. Country Studies Program, Guidance for Mitigation Assessments: Version 2

MODULE 5: CLIMATE CHANGE MITIGATION ANALYSIS

Session 12: Reporting a Mitigation Assessment

Overview

General Objectives: By the end of the session, participants should have a clear understanding of how to go about reporting the findings of the mitigation assessment. Specifically:

- General recommendations for national assessment reporting
- Key components of the report
- Developing cost curves and plotting GHG baseline and mitigation scenarios

Activities: An overhead slide presentation, followed by period of questions and answers

Total Time: 45 minutes

Materials: Set of 15 OHTs

Reporting a Mitigation Assessment

Module 5: Session 12

CCI - Ukraine Workshop Package

Reporting Results

Slide 1

General Recommendations for Reporting National Mitigation Assessments

- Present energy and non-energy separately
- Present the main findings from each sector, as well as from integrated analyses, in a summary
  - Summary description of mitigation options
  - National GHG emissions scenarios

General recommendations for sectoral mitigation assessments are outlined in the following slides:

Reporting Results

Slide 2

Key Components of Energy Sector Reporting

- Model description
- Scenario assumptions and input data
  - General scenario assumptions
  - Projections of activity levels
  - Projections of energy intensities
  - Description of energy resources and technologies
  - Emission coefficients
- Scenario definitions
  - Baseline definition (key assumptions in the scenario)
  - Mitigation definition (differences from baseline assumptions)

Key Components of Energy Sector Reporting (ctd.)

- Results
  - GHG emissions for all scenarios
  - Energy use (primary, electricity generation, final)
  - Cost of emission abatement (additional energy system costs, cost structure, cost curves
  - Contribution of technology options to GHG abatement
  - Other environmental impacts
  - Summarize evaluation of options
- Macroeconomic impacts
- Policy options

Results of Technology Options Assessment

Typical output of technology assessment calculations should appear as shown below:

- Cost Data
- Process Efficiency
- Lifetime
- Operation & Maintenance Cost
- Fuel Consumption
- Diffusion:
  - rate
  - limit
- Engineering Data
- Total GHG reduced per year
- Total GHG reduced by 2030
- Cost of Reduction per ton
- Energy Saving

Reporting Results Slide 5

Two Most Important Outputs:

- GHG emissions reduced in tons
- Cost of the investment (for the mitigation technology) relative to each ton of GHG reduced ($/ton CO_2)
  - These are the building blocks of an abatement cost curve
  - Additional pieces of information are:
    - Time Horizon or Reduction Period
    - Reduction Targets

Reporting Results Slide 6

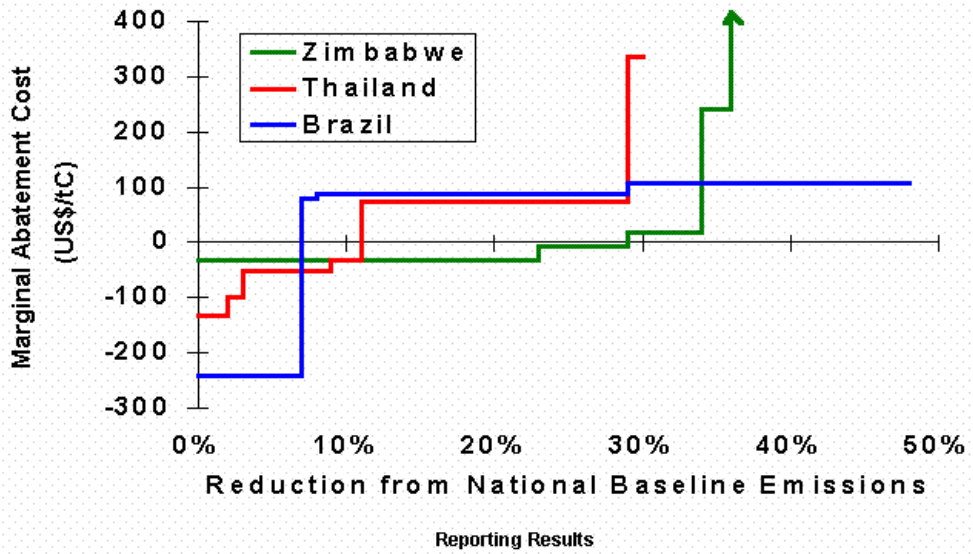
Cost Curves

- A technique for screening and ranking GHG mitigation options.
- Plot cumulative GHG reduction from successive mitigation options (e.g. tonnes of CO2 avoided) against cost per unit of GHG reduction (e.g. $/ton).
- Area under curve yields total cost of avoided emissions.
- Interdependencies among options should be considered carefully (e.g. benefits such as fuel switching in electric sector may be reduced by end-use efficiency programs).

Reporting Results

Slide 7

Abatement Cost Curve, UNEP Studies



Reporting Results

Constructing Mitigation Scenarios Cost Curve

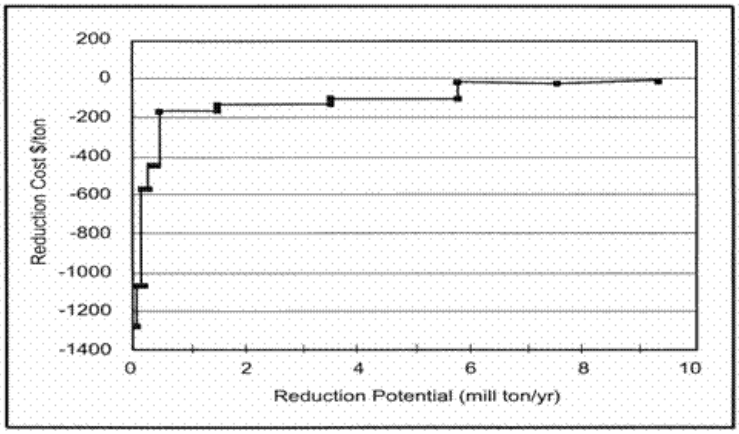
- Steps in creating a cost schedule (using a spread sheet):
  - Make a list of all reduction cost output in one column
  - Make a list of tons of CO_2 reduced in another column
  - Sort the data in both columns using cost as the primary sort key
  - Plot the graph with cost on "y" and tons on the "x" axis
  - Result is a mitigation cost curve, shown in following slides

Reporting Results Slide 9

Typical Structure of Cost Curve

Example A

A. Negative Cost Options

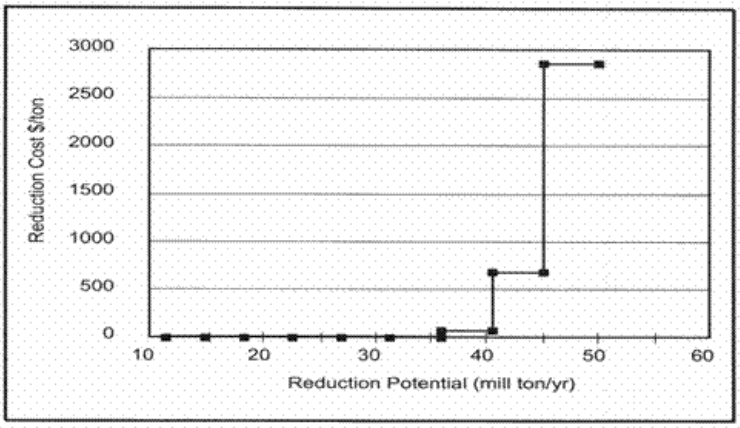


Reporting Results Slide 10

Typical Structure of Cost Curve

Example B

B. Only Positive Cost Options



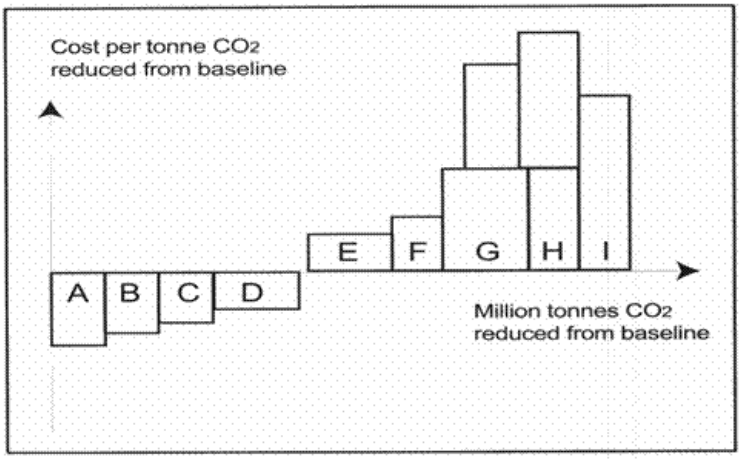
Reporting Results

Slide 11

Typical Structure of Cost Curve

Example C

Discrete Step CO_2 – Reduction Cost Curve



Reporting Results

Slide 12

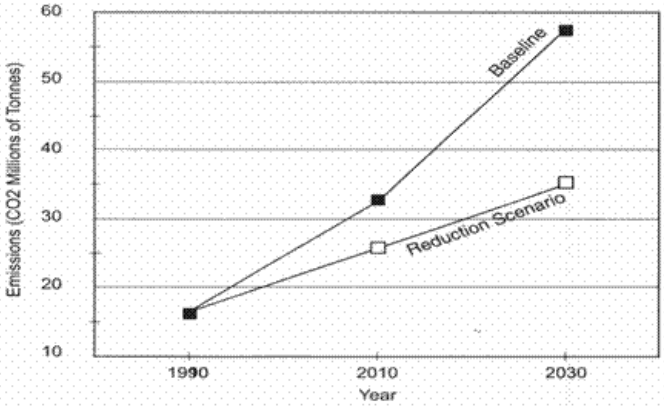
Typical Cost Curve Characteristics

- Reduction scenario is a series of mitigation options implemented over time
- Options are superimposed on emission growth due to growth in demand
- Options are superimposed on effects of AEEI
- Reduction scenario achieves lower carbon intensity but not lower productivity
- Emissions are usually not discounted

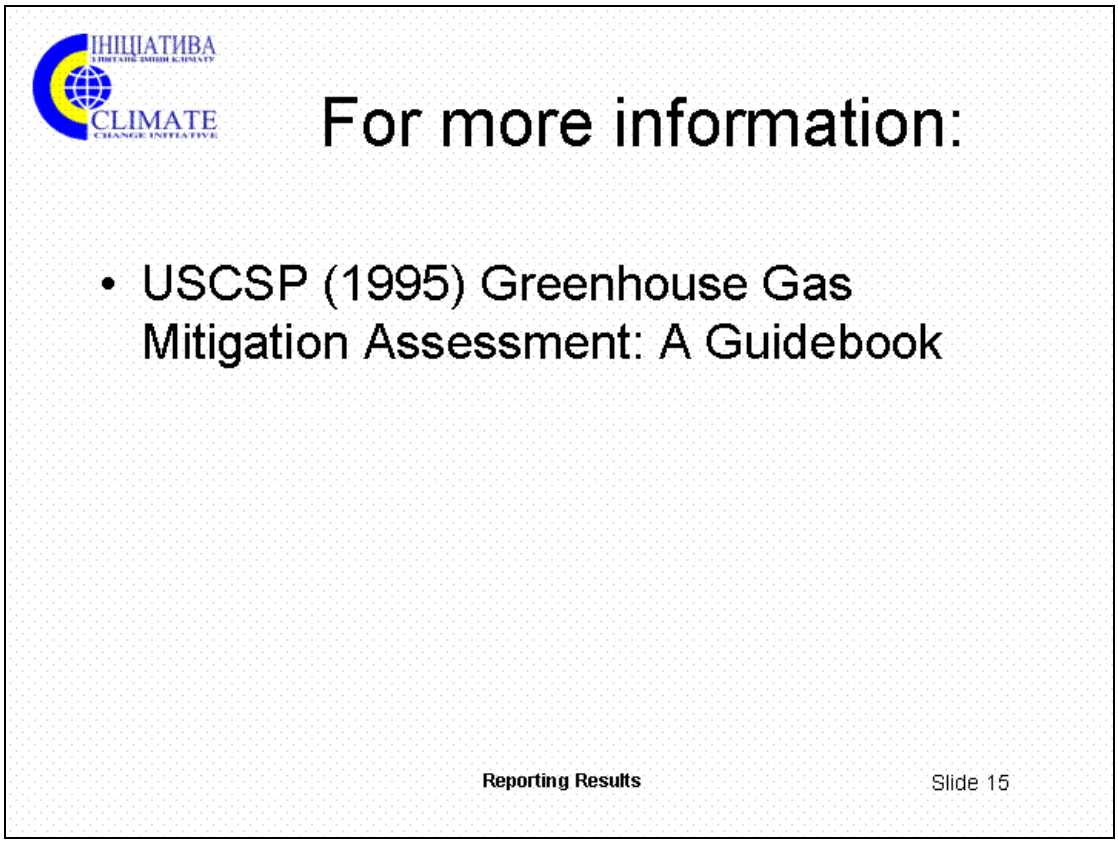
Reporting Results Slide 13

Plotting and Comparing Baseline & Mitigation Scenarios

The mitigation scenario can be outlined by plotting baseline emissions less the emissions reduced by introducing abatement options



Reporting Results Slide 14


For more information:
• USCSP (1995) Greenhouse Gas Mitigation Assessment: A Guidebook
Reporting Results
Slide 15

Working Group Exercise #2

General Objectives: This session is a working group exercise ideally led by one or more local specialists. Depending on the size of the audience, it can be led in the large group (if the workshop audience is less than 30 people), or by splitting up into 2 or more small groups (if the workshop audience is greater than 30 people). The purpose is to lead participants in a thought exercise to identify major barriers and actions necessary to develop projects that were identified as most promising in Exercise #1.

	Legal	Institutional	Informational	Economic
Types of Barriers				
Domestic Actions Needed				

Activities: High level of audience participation identify barriers to achieving investments in carbon-reducing technologies in Ukraine, and exploring domestic actions that could be taken to address those barriers.

Total Time: 60 minutes

Materials: None

Training Module Evaluation Form

Title of Module: Greenhouse Gas Mitigation Analysis Module # 5 Date:

For each statement below, mark the circle on the scale that corresponds to your opinion.

		Evaluation score					
		1	2	3	4	5	
1. The presentation of this module was	Unclear	O	O	O	O	O	Clear
2. The objectives of this module were	Not important	O	O	O	O	O	Important
3. The information presented in this module was	Not sufficient	O	O	O	O	O	Sufficient
4. The information presented in this module was	Not useful	O	O	O	O	O	Useful
5. The exercises in this module were	Not interesting	O	O	O	O	O	Interesting
6. The knowledge acquired through this module was	Insignificant	O	O	O	O	O	Important
7. Participating in this module enable you to learn	Nothing new	O	O	O	O	O	Many new things

What did you like most about this module? _____

_____

What did you like least about this module? _____

_____

What is your opinion on presenters? _____

_____

What is your opinion on organization of this module? _____

_____

On what themes presented in the module would you like to get more information? _____

_____

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What module themes would be interesting for you in the future? _____

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Comments: _____

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